

What is claimed is:

1. A multi-wavelength photonic oscillator comprising:

(a) a plurality of lasers each emitting light at a different frequency;

(b) an optical wavelength multiplexer for combining the light emitted by the plurality of lasers at an output thereof as a set of optical wavelengths; and

(c) an optical modulator arranged in a feedback loop and coupled to receive light at the output of the optical wavelength multiplexer, the feedback loop further including:

(i) an optical tap for coupling at least a subset of said set of optical wavelengths to at least one optical output of the multi-wavelength photonic modulator;

(ii) at least one optical channel having an associated photodetector arranged to receive light from the optical tap via the at least one optical channel; and

(iii) an electronic loop portion coupled to receive output from the at least one associated photodetector and to provide an input for the optical modulator.

2. The multi-wavelength photonic oscillator of claim 1 wherein the feedback loop has a plurality of optical channels with one optical channel imposing more delay than another optical channel with each associated photodetector in the plurality of optical channels having an output combined at a common electrical output for connection to said electronic loop portion.

3. The multi-wavelength photonic oscillator of claim 2 wherein at least one of an optical portion of the loop and the electronic loop portion includes an amplifier to ensure that a loop gain for the feedback loop exceeds unity.

4. The multi-wavelength photonic oscillator of claim 3 wherein at least one of the optical portion of the loop and the electronic loop portion includes phase shifting

means.

5. The multi-wavelength photonic oscillator of claim 4 wherein the electronic loop portion includes a bandpass filter and wherein the input for the optical modulator is an electronic input.

5 6. The multi-wavelength photonic oscillator of claim 1 wherein the optical tap is wavelength sensitive for directing light of a wavelength associated with a frequency of one of the lasers of said plurality of lasers into said feedback loop and for directing light of wavelengths associated with frequencies of other ones of the lasers of said plurality of lasers to said at least one optical output of the multi-wavelength photonic modulator.

10 7. The multi-wavelength photonic oscillator of claim 6 wherein the feedback loop has a plurality of optical channels with one optical channel imposing more delay than another optical channel with each associated photodetector in the plurality of optical channels having an output combined at a common electrical output for connection to said electronic loop portion.

15 8. The multi-wavelength photonic oscillator of claim 7 wherein at least one of an optical portion of the loop and the electronic loop portion includes an amplifier to ensure that a loop gain for the feedback loop exceeds unity.

20 9. The multi-wavelength photonic oscillator of claim 8 wherein at least one of the optical portion of the loop and the electronic loop portion includes phase shifting means.

10. The multi-wavelength photonic oscillator of claim 9 wherein the electronic loop portion includes a bandpass filter and wherein the input for the optical modulator is an electronic input.

11. The multi-wavelength photonic oscillator of claim 1 wherein said feedback loop includes a plurality of parallel-arranged optical channels and wherein the optical tap is wavelength sensitive for directing light of wavelengths associated with frequencies of said plurality of lasers each into different ones of optical channels of said feedback loop.
- 5 12. The multi-wavelength photonic oscillator of claim 11 wherein at least one of the optical channels imposes more delay than at least another one of the optical channels, each optical channel having an associated photodetector with a photodetector output, the outputs of the photodetectors in said optical channels being combined at a common electrical output for connection to said electronic loop portion.
- 10 13. The multi-wavelength photonic oscillator of claim 12 wherein at least one of an optical portion of the loop comprising said optical channels and the electronic loop portion includes an amplifier to ensure that a loop gain for the feedback loop exceeds unity.
14. The multi-wavelength photonic oscillator of claim 13 wherein each optical
15 channel in the optical portion of the loop has an optical amplifier.
15. The multi-wavelength photonic oscillator of claim 13 wherein at least one of the optical portions of the loop and the electronic loop portion includes phase shifting means.
16. The multi-wavelength photonic oscillator of claim 15 wherein each optical
20 channel in the optical portion of the loop has an optical amplifier and phase shifting means.
17. The multi-wavelength photonic oscillator of claim 16 wherein the electronic loop

portion includes a bandpass filter.

18. The multi-wavelength photonic oscillator of claim 1 in combination with:

(d) a wavelength division demultiplexer coupled to the at least one optical output of the multi-wavelength photonic oscillator; and

5 (e) a plurality of slave lasers arranged as pairs of slave lasers, each pair of slave lasers being wavelength-associated with a laser of said plurality of lasers in said multi-wavelength photonic oscillator and being coupled to said multi-wavelength photonic oscillator via said wavelength division demultiplexer.

10 19. The apparatus of claim 18 wherein one slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a modulation sideband in the optical signal supplied by the multi-wavelength photonic oscillator.

20. The apparatus of claim 19 wherein the other slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a different modulation sideband in the optical signal supplied by the multi-wavelength photonic oscillator.

15 21. The apparatus of claim 18 wherein one slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a carrier frequency in the optical signal supplied by the multi-wavelength photonic oscillator.

20 22. The apparatus of claim 21 wherein the other slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a modulation sideband in the optical signal supplied by the multi-wavelength photonic oscillator.

23. The apparatus of claim 18 in combination with a radar or other communication system having optical modulators for modulating signals transmitted thereby, the pairs of slave lasers each producing a local oscillator signal for modulation by the optical

modulators in said radar or other communication system.

24. A transmitter comprising:

(a) optical modulators for modulating optical local oscillator signals;

(b) photodetectors coupled to outputs of the optical modulators for converting
5 the modulated optical local oscillator signals to electrical radio frequency signals for
subsequent application to antenna elements; and

(c) an apparatus for generating the optical local oscillator signals comprising:

(i) multi-wavelength photonic oscillator; and

(ii) a wavelength division demultiplexer coupled to an optical output of
10 the multi-wavelength photonic oscillator, said wavelength division
demultiplexer separating the optical output into more than one
wavelength region with the optical output at each wavelength region
comprising at least an optical carrier and a modulation sideband, the
output at each wavelength region being suitable for determining a local
15 oscillator frequency.

25. The transmitter of claim 24 wherein the apparatus for generating the optical local
oscillator signals further comprises a plurality of slave lasers arranged as pairs of slave
lasers, each pair of slave lasers being wavelength-associated with said multi-wavelength
photonic oscillator and being coupled to said multi-wavelength photonic oscillator via
20 said wavelength division demultiplexer.

26. The transmitter of claim 25 wherein one slave laser in each said pair of slave
lasers is set so that its free-running wavelength matches a modulation sideband in an
optical signal supplied by the multi-wavelength photonic oscillator.

27. The transmitter of claim 26 wherein the other slave laser in each said pair of slave
25 lasers is set so that its free-running wavelength matches a different modulation

sideband in the optical signal supplied by the multi-wavelength photonic oscillator.

28. The transmitter of claim 25 wherein one slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a carrier frequency in an optical signal supplied by the multi-wavelength photonic oscillator.

5 29. The transmitter of claim 28 wherein the other slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a modulation sideband in the optical signal supplied by the multi-wavelength photonic oscillator.

30. The transmitter of claim 24 wherein the multi-wavelength photonic oscillator comprises:

- 10 (1) a plurality of lasers each emitting light at a different frequency;
(2) an optical wavelength multiplexer for combining the light emitted by the plurality of lasers at an output thereof as a set of optical wavelengths; and
(3) an optical modulator arranged in a feedback loop and coupled to receive light at the output of the optical wavelength multiplexer, the feedback loop further including:
15 an optical tap for coupling at least a subset of said set of optical wavelengths to at least one optical output of the multi-wavelength photonic modulator;
at least one optical channel having an associated photodetector arranged to receive light from the optical tap via the at least one optical channel; and
20 an electronic loop portion coupled to receive output from the at least one associated photodetector and to provide an input for the optical modulator.

31. A receiver comprising:

- (a) optical modulators for modulating optical local oscillator signals;
(b) photodetectors coupled to outputs of the optical modulators for converting
25 the modulated optical local oscillator signals to an electrical intermediate frequency or

baseband signal for subsequent processing; and

(c) an apparatus for generating the optical local oscillator signals comprising:

(i) multi-wavelength photonic oscillator; and

(ii) a wavelength division demultiplexer coupled to an optical output of the multi-wavelength photonic oscillator, said wavelength division demultiplexer separating the optical output into more than one wavelength region with the optical output at each wavelength region comprising at least an optical carrier and a modulation sideband, the output at each wavelength region being suitable for determining a local oscillator frequency.

32. The receiver of claim 31 wherein the apparatus for generating the optical local oscillator signals further comprises a plurality of slave lasers arranged as pairs of slave lasers, each pair of slave lasers being wavelength-associated with said multi-wavelength photonic oscillator and being coupled to said multi-wavelength photonic oscillator via said wavelength division demultiplexer.

33. The receiver of claim 32 wherein one slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a modulation sideband in an optical signal supplied by the multi-wavelength photonic oscillator.

34. The receiver of claim 33 wherein the other slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a different modulation sideband in the optical signal supplied by the multi-wavelength photonic oscillator.

35. The receiver of claim 32 wherein one slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a carrier frequency in an optical signal supplied by the multi-wavelength photonic oscillator.

36. The receiver of claim 35 wherein the other slave laser in each said pair of slave lasers is set so that its free-running wavelength matches a modulation sideband in the optical signal supplied by the multi-wavelength photonic oscillator.

37. The receiver of claim 31 wherein the multi-wavelength photonic oscillator comprises:

- (1) a plurality of lasers each emitting light at a different frequency;
- (2) an optical wavelength multiplexer for combining the light emitted by the plurality of lasers at an output thereof as a set of optical wavelengths; and
- (3) an optical modulator arranged in a feedback loop and coupled to receive light at the output of the optical wavelength multiplexer, the feedback loop further including:
 - an optical tap for coupling at least a subset of said set of optical wavelengths to at least one optical output of the multi-wavelength photonic modulator;
 - at least one optical channel having an associated photodetector arranged to receive light from the optical tap via the at least one optical channel; and
 - an electronic loop portion coupled to receive output from the at least one associated photodetector and to provide an input for the optical modulator.